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STEAM-TRAIL map: A roadmap for European Higher Education Institutes to implement Transdisciplinary Innovation Labs

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Abstract

Human development has spurred hypercomplex issues like pandemics and climate change, unmanageable through STEM-alone approaches. Addressing these demands collaboration across all academic (including non-STEM disciplines) and non-academic fields, necessitating a transdisciplinary approach. Higher education should cultivate 21st-century skills, like those in TRAnsdisciplinary Innovation Labs (STEAM-TRAIL), enabling adept collaboration on multifaceted problems within diverse groups. Through a Design-based research (DBR) approach, this manuscript explores the views and needs for transdisciplinarity in higher education from different participants (teachers, students, and policymakers) from 9 European countries that were involved in the STEAM+ research project funded by the EU ERASMUS+. The results of this study contributed to the creation of a transdisciplinary conceptual model for implementation: the STEAM-TRAIL map. Addressing stakeholder needs for closer collaborations, clearer examples, and actionable steps, the map serves as a repository of STEAM+ project insights, guiding universities across Europe in initiating their STEAM-TRAILs and offering structured knowledge and experiences.

Keywords: Talent Programmes; Transdisciplinarity; Honours Pedagogy; STEM Education; innovation lab

1. Introduction

Europe faces grand challenges which have science, technology, engineering, and mathematics (STEM) subjects at their core, such as climate change and energy transition. But the complexity of these challenges has proven that the capacity of traditional approaches comes short in yielding expected results (Organisation for Economic Co-operation and Development [OECD], 2017). Within educational policies and research at international level a shift towards inner transformation and well-being of students is emerging to help new generations navigate the complexity of the 21st century (Martin, 2018; Care & Luo, 2016; Ives et al., 2023). Some authors argue that complex or "wicked" (Rittel & Webber, 1973; Alford & Head, 2017) societal problems need a transdisciplinary approach (Xiang, 2013; McGregor, 2015; Head & Xiang, 2016; Conner, 2022). Transdisciplinarity "is defined by the integration of academic researchers from unrelated disciplines and non-academic participants in creating new knowledge and theory to achieve a common goal. […] All transdisciplinary efforts involve interdisciplinarity, but the number of disciplines involved and the epistemic distance among them will vary with the problem being addressed" (OECD, 2020, p. 25).

Questions arise about how researchers and future professionals need to be educated if they are to deal with the complexity of current global and societal challenges. It is inherent to transdisciplinary research that scientific knowledge is augmented through the integration of insights from different academic and non-academic fields (Lawrence et al., 2022; Hirsch-Hadorn et al., 2008). To perform or contribute to this research in an effective and methodological way, transdisciplinary scientists and future professionals need to be trained in skills and competencies to cope with the complexity of wicked problems (Derry & Fischer, 2005; Kawa, et al., 2021) to work with each other across academic disciplines and crossing academic and non-academic boundaries. However, current structures of higher education

and the curricula of students mainly focus on a disciplinary formation (Budwig & Alexander, 2020; Yeung et al., 2021; Daneshpour & Kwegyir-Afful, 2022). In addition, there remains little material available for teachers and institutions on how to implement transdisciplinarity into curricula (Nash, 2008; Yeung et al., 2021; Horn et al., 2022).

Transdisciplinary education has gained recognition as a promising approach to complex, global challenges and to enhance students' innovation-, thinking-, and collaboration competences (Eronen et al., 2019; OECD, 2020; Remington-Doucette et al., 2013; Pohl et al., 2018). Taking part in transdisciplinary programmes is believed to better prepare students for their future careers (Roy et al., 2020; World Economic Forum (WEF), 2023). Employers are increasingly searching for employees who possess the competences to be able to adjust to the complex changes in society (ManpowerGroup, 2023; McGunagle & Zizka, 2020; WEF, 2023). Yet it remains difficult for forms of transdisciplinary education to be implemented into higher education (Bernstein, 2015; Horn et al., 2022). A major challenge for transdisciplinary learning and development are the rigorous structures of higher education institutes (Budwig & Alexander, 2020; Vilsmaier et al., 2023). Extra-curricular programmes such as talent or honours programmes are less restricted to the institutional requirements (Wolfensberger, 2015a; Kolster, 2021). They provide teachers and institutions an opportunity to experiment with multidisciplinary, interdisciplinary, and transdisciplinary learning (e.g. Carmichael, 2008; Ceulemans et al., 2019; Tariq et al., 2022).

Honours programmes in higher education offer the opportunity of a deeper, more meaningful, and transformative learning experience to students (Wolfensberger, 2012). Built around the three pillars of honours pedagogy these programmes offer bounded freedom (see also: Kingma et al., 2018; 2024), engender academic competences (see also: Canrinus et al., 2020) and create a committed community (see also: Heijne-Penninga & Wolfensberger, 2018; Canrinus et al., 2021). Additionally, they can function as laboratories for educational innovation (Holman et al., 2009), allowing for teachers to experiment with new teaching strategies and innovative pedagogies to emerge (Austin, 1991; Wolfensberger et al., 2004).

The STEAM+ project as investigation context

This manuscript follows the EU funded Erasmus+ project: *Innovating STE(A)M in Higher Education with Transdisciplinary Talent Programmes* (www.steamtalent.eu). The project started from the recommendation on Key Competences for Lifelong Learning by the council of the European union (2018) which raised a need for innovating European higher education with "new and innovative forms of teaching and learning" (p. 2). Throughout the project three transdisciplinary talent programmes (STEAM-TRAILS) were designed and tested as innovation laboratories. These innovation labs provided a space for students to experiment with innovative approaches to wicked societal challenges and to collaborate with multiple disciplines and non-academic stakeholders. They allowed the investigators to learn about the steps of implementation and to subsequently discuss intermediary results with stakeholders.

The focus on a STEAM approach builds upon the growing interest in STEM-focused educational programmes to address the international shortage of STEM professionals (Ritz & Fan, 2015). The STEAM+ researchers add an 'A' (All other) to the acronym of STEM to augment education to better reflect real-world problems through talent or honours programmes in the format of transdisciplinary innovation labs ('+'), hence adopting the acronym STEAM+.

STEAM+ investigators aimed to provide higher education institutes and educational policy makers with instruments and insights to strengthen higher education and help to prepare new generations and researchers for addressing the challenges of our time. Considering the need for transdisciplinarity in higher education and the variety of the participants in the STEAM+ project activities, the present study intends to explore the views, needs and experiences of the participants of STEAM+.

The following research question guides this manuscript: How can transdisciplinary innovation labs be implemented across Europe?

2. Methods

We used a design-based research approach (McKenney & Reeves, 2013; Joseph, 2004; Hoadley, 2004) to learn about the steps of implementation and disseminate and discuss intermediary results with stakeholders. New questions emerged throughout the project such as: 'How can and how should a STEAM-TRAIL be formatted, what stepping stones are needed for implementation, at what stages and how are different stakeholders involved in the implementation process?' The data presented was gathered to inform policy makers, students, teachers, and higher educational board and policy representatives about implementation of transdisciplinary honour's programmes.

Design-Based Research Protocol for STEAM-TRAIL Implementation 2

The research methodology adopted for this study is based on a design-based research (DBR) approach (McKenney & Reeves, 2013; Joseph, 2004; Hoadley, 2004). DBR is a methodology used to carry out educational research in the real world, leading to results that contribute to both scientific knowledge and practice. The goal of applying DBR in this research was twofold: to develop an effective implementation strategy for STEAM-TRAILs and to refine the theoretical frameworks that guide transdisciplinary education. According to the suggestions of Wang and Hannafin (2005), this research was organised through three design research cycles over 3 years, which are shown in figure 1. The research cycles followed the organisation of innovative laboratories in the scope of the STEAM+ Erasmus Plus project.

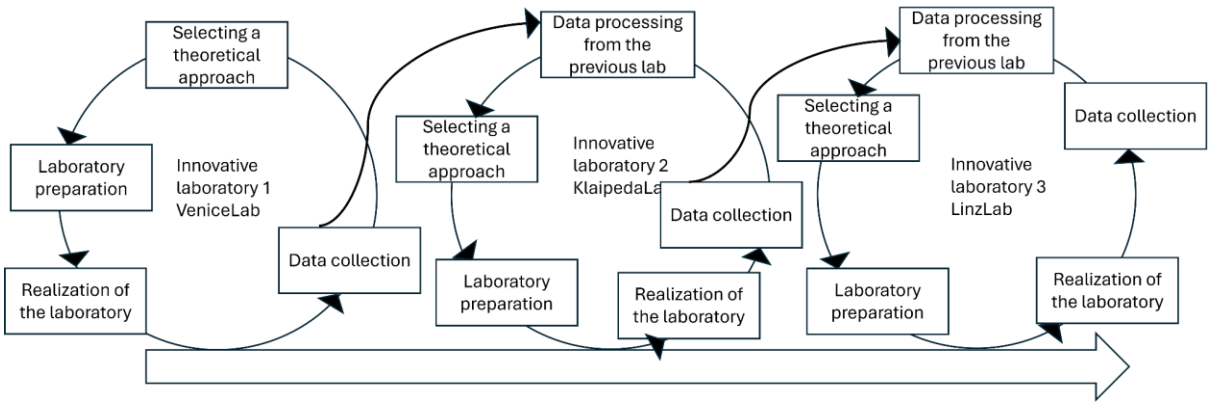

Figure 1: Design and activities for the application of DBR in this research

In accordance with the principles of Wang & Hannafin, (2005) regarding the DBR methodology our research project involved cycles of design, implementation, evaluation, and refinement. This iterative process was crucial for adapting the STEAM-TRAIL design based on real-time

feedback and emerging educational needs. The data collected in the first laboratory were used as indicators for improvement, subsequently applied to laboratory two. In similar style, the data collected in laboratory two were used for the improvement of laboratory three. Also, with each innovation lab, educational interventions were tested with participants, and data collected through surveys and observations. We used content analysis of data, allowing rapid adjustment of the next lab. In this way, a flexible method for continuously improving materials and strategies from one research phase to the next was achieved. This research approach was vital to understanding the practical implications of STEAM-TRAILs and making the necessary modifications in real time.

Participants

Participants in this research were recruited using snowball sampling (Dosek, 2021) and were recruited by the project partners independently. All universities distributed an invitation to teachers, students, experts, and policymakers to participate in the project and asked them to share the invitation with colleagues they think are interested. This resulted in a total of 125 participants at our three innovation labs at the universities of Venice, Klaipeda, and Linz respectively. The participants were engaged through various stages of the research and provided data through multiple channels. Table 1 displays the number of participants from each group and their role of involvement.

Table 1. Study Participants.

Type of participants:	n	Role in Labs:
Students	53	Participated in innovation labs at each university, providing feedback through surveys, diaries and participating in discussions.
Teachers	28	Involved in teaching, facilitating and organizing the labs, providing insights through surveys and interviews.
Policy Makers	13	Engaged in policy meetings, Labs and interviews, providing strategic insights into higher education policies.
Experts	31	Provided insights from supportive roles during the labs, giving presentations to teachers and students on methods and tools to work on wicked challenges.

Contents of research – Innovation lab descriptions

Each lab had a unique focus and format, aimed at addressing sustainability challenges of the host university. The first innovation laboratory was held in Venice, on the topic of Citizen Science for the Protection of the Sea. This laboratory was organised as a one-week summer school. Theory U (Scharmer, 2009; 2018) was used as the theoretical basis for this laboratory, on which all activities were designed. The participants of this laboratory dealt with various

aspects of marine protection, as well as city architecture, exploring innovative methods for involving citizens in scientific endeavours that support the sustainability of marine ecosystems through field trips, storytelling, workshops and panel discussions. The unique location of Venice provided the participants with a diverse and hands-on experience, making the acquisition of knowledge more relevant and applicable. This immersive environment helped participants not only learn about, but also directly engage with the practical and complex aspects of marine conservation efforts.

The University of Klaipeda organised the second laboratory. Klaipeda is a harbour town in Lithuania and faces challenges in balancing sea - and city health. Due to travel restrictions caused by the COVID-19 pandemic, this lab was conducted entirely online over the course of two weeks. The focus of the lab was therefor changed to local sustainability challenges in the hometowns of the participating students. Theory U was again applied for the organisation. The virtual format consisted of introductory sessions that included online presentations by sustainability experts. After these introductions, students collaborated locally with their teachers to design solutions to sustainability challenges specific to their regions. The students created short videos as their outputs, which were presented at a final plenary (online) event visited by various stakeholders from all the different countries. This approach not only encouraged creativity, but also allowed participants to apply their ideas in a way that directly benefits their local communities.

The Johannes Kepler University in Linz was the host of the third laboratory, which was focused on the development of fun solutions for social challenges. This laboratory was organised as a one-week winter school, where students applied the STEAM+ approach to solving current social problems. In addition, the winter school included a focus on bridging high schools and tertiary education institutes through a STEAM+ approach. The week was filled with workshops, presentations and moderated discussions that introduced students to various social challenges. As a theoretical basis for the organisation of this laboratory, the approach of constructivist learning (Hein,1991; Anđić et al., 2021) was used. Participants first defined specific problems that interested them and then jointly developed innovative approaches. Those approaches were later displayed via infographics, providing a visual and engaging way to demonstrate their ideas. This lab format aimed to enhance learning and empower students to think critically and creatively about real-world problems.

Data collection

In this research, data was primarily collected from the innovation labs. Additional data was gathered from policy maker interviews, surveys, note-taking and recordings during national and international policy meetings, and a theory of change exercise. This additional data allowed for verifying and further deepening of what was collected during the innovation labs. After processing all data was implemented into the STEAM+ final products STEAM-TRAIL map. The main collected data type was qualitative. Table 2 provides an overview all different data-collection activities.

Table 2: Overview of data collection activities

Year	Measurement Moment	#	Method	Participant (n)	Data type
2020	Frontrunner interview	7	Semi-structured Interview	Policy Partner (7)	Qualitative
2020-2023	National policy Meetings	81	Semi-Structured Focus group	Policy maker (educational staff, student)	Qualitative
2021-2023	Post-lab evaluation survey	3	Mixed survey with open and closed questions	Student (53), Teacher (28), Expert (31), Policy maker (13)	Quantitative and Qualitative
2023	International Policy Meeting	1	Structured interview	Policy maker (8)	Qualitative
		1	Theory of change exercise	Policy maker (5), Student (2), Teacher (5), research manager (3)	Qualitative
2023	Online questionnaire	3	Open-ended questionnaire	Student (6), Teacher (2), Policy Partner (1)	Qualitative

In early 2020, structured interviews were conducted with seven policy partners from five different countries to gain insights into challenges in higher education for transdisciplinary innovation labs, which laid the groundwork and input for further discussions. These interviews were recorded and analysed with MAXQDA and qualitative content analysis (Mayring, 2000) and used to guide the initial rounds of policy meetings. During the project, the three innovation labs were excellent occasions for data collection through post-lab evaluation surveys. These surveys included both Likert-scale and open-ended questions, providing valuable feedback on lab effectiveness and areas for improvement. Table 3 shows the total amount of responses from each participant role for every innovation lab.

Table 3: Responses to Post-lab Evaluation Surveys

	Venice lab	Klaipeda Lab	Linz Lab
Student	8	12	8
Teacher	7	7	6
Expert	2	3	2
total	17	22	16

At the international policy meeting structured interviews and the creation of individual theories of change (Armitage et al., 2019; Serrat, 2017) provided a deeper understanding of the policy makers' views on approaches to transdisciplinary education. In total eight policy makers were interviewed. The interviews were audio-recorded, transcribed, and compiled. The analyses of these interviews provided us with insights on the policy makers' views.

During the theory of change exercise participants wrote individual theories of change which were collected and categorised based on the role of the participant. Subsequently these theories of change were compiled into joint theories of change by two researchers from project partner KU Leuven. In total 15 people participated. Five participants identified as teachers, two participants as students and five participants as policy makers. The three remaining participants identified themselves as research managers.

Intermediary results were shared throughout the project with educational stakeholders through three rounds of three national policy meetings in every partner country. These meetings played a key role in synthesising insights from different data sources and different contexts. During these meetings recent activities were shared to national policy makers, students, and higher education staff. They included discussions based on structured reports from each laboratory. These reports were subsequently compiled, shared among partners, and used to refine educational and policy strategies.

Further questions arising through analysis of post-lab surveys were posed to participants through an online questionnaire to deepen our understanding and validate collected data. This questionnaire was sent out by e-mail to the students, teachers and associated policy makers at the end of the project, after the three innovation labs. For example, how would students see themselves taking part in preparing a STEAM-TRAIL, what questions and needs remain for teachers after taking part in these STEAM-TRAILs, at what stages can policy makers be involved in the implementation process? The design and data analysis of the online questionnaires were done in collaboration with an honour's student from University of Utrecht. She designed a set of open-ended questions for each role together with the KU Leuven partner, responsible for the work package of the STEAM-TRAIL map. Table 4 shows the response rates for the questionnaire from each role.

Table 4: Response rates to online questionnaire

Role	Response Rate
Student	35, % (6 out of 17)
Teacher	15,2 % (2 out of 13)
Policy maker	14,2 % (1 out of 7)

All collected data—including audio files, survey responses, and meeting notes—are systematically stored on a shared SharePoint drive. This centralised storage enabled joint analysis by all researchers involved in this project, allowing an iterative learning process and adjusting the project's focus according to emerging insights. This methodological rigour ensured that the project not only captured a wide range of perspectives, but also dynamically responded to the evolving educational landscape.

3. Results

In this section the results that were gathered through the design-based research of the innovation labs is presented. All quotes and paraphrases from policy makers, teachers, and students presented below have been anonymised.

Frontrunner interviews

In the frontrunner interviews 7 policy makers were asked about what new struggles higher education faces regarding the past. Policy maker 1 pointed at "the number of enrolments in higher education is a lot higher than 40 years ago" (Policy maker 1), while policy maker 2 argued that the complexity of the world has grown:

> "there was a clear place for the university in a world that in many respects was 'easier', that is less global, less interacting, and less aware of global issues. While now the situation is drastically changed. We leave and need to navigate in a more complex world, where there are much fewer 'handbooks' to solve the problem. A world which is more interactive and where problems not always allow for easy solutions." (Policy Maker 2).

Policy maker 3 reasoned that the goal of higher education and its educators had changed:

> "Students are encouraged to be more self-regulated, to think more independently and to be more independent from their teachers. The goal is to become an independent professional and it is not about transferring knowledge from teacher to student and then bring it into practice. The relationship between teacher and student has become more equal than it was in the past. Problems nowadays are so complicated that teachers don't have all the answers and they become learners as well, being role models for life long learning." (Policy maker 3).

The policy makers pinpointed the fact that there is an urgent need for educating students to address the complex challenges our world faces, as the following quote from policy maker 4 shows:

> "The people who have and will make decisions in the next 5 years they all have attended universities at some point and they are failing to approach these problems adequately and they have failed because we are facing these problems."

Nevertheless, some good evolutions mentioned by some interviewees were the use of mechatronics in Austria, innovation labs on complex problems in the Netherlands, and agreements between institutions and the labour market in Norway.

When asked if honours programmes could leverage innovation in higher education the interviewed policy makers replied positively, stating that honours programmes "help students learn to be more independent, self-regulated and to discover their own professional identity," (Policy maker 3) and that, "all types of programmes that have more freedom in critically thinking and can do things differently are very welcome and are frontrunners in making some shifts possible." (Policy maker 5) One policy maker saw the potential in the small group of participants as "one can carry out more targeted studies and experiments, for example, innovation labs and testing of tools before spreading them to the masses." (Policy Maker 6). This transformative potential of honours programmes also returned in the answer of policy maker 1:

> "They can represent one of the seeds from which new ideas stem, they may represent test beds of new good practices that can be the extended to the whole higher education system. But honours programmes too need to innovate, to think different than before. honours programs cannot be the same as thirty years ago. They need to take big risks, to be on the forefront of innovation." (Policy maker 1).

A way of innovating honours programmes is through transdisciplinary learning. The Policy makers tended to agree with this statement. For example, policy maker 1 said:

> "It is important to cross over the disciplines. We need deep knowledge but also to be able to put that knowledge into a context and into society. We need society as an expert in order to get a higher perspective on problems and solutions." (paraphrased).

However, most policy makers were careful to fully agree. They indicated several obstacles to transdisciplinary honours programmes such as: "it's a huge job for students to work together, especially the different schedules are the problem" (Policy maker 3), and policy maker 7 noted that there are a lot of practical obstacles:

> "it takes more time and effort from lecturers to organise this kind of approach, and most of the time it is very rewarding. However, the career evaluation policy at university level does not always take these efforts into account. Other practical obstacles are the faculty boundaries, differences in accreditation among faculties make it difficult for students to collaborate within one course." (Policymaker 7).

The interviewees showed an awareness for innovation of higher education, yet also shared a sense that urgency is missing to redesign educational policies. When asked how policy makers and higher education institutes may help strengthen the transformative potential of honours programmes they said: “more money would help, developing own programmes and studies” (Policy maker 6), “open up and listen to the concerns that often remain unheard amongst academic staff and students” (policy maker 5), “everyone should be a policy maker, otherwise it is undemocratic” (policy maker 3), and “they have an important role in showing the pathway and should set high quality standards for higher education.” Furthermore, a long-term vision is needed in higher education policies that relate to the changes in society.

> “Policy makers foster the adaptation of higher education to the 21st century skills or demands. What I even see in my own university is that policymakers are looking to making policy and they are they have ideas about how education suits should develop from education itself. So, I would really encourage them to have a look outside of the university what's happening there, what changes are there, how have as our views on students and professional identity changed, what does that mean for our education now, should we change our education to keep up with these kind of changes, and I think the second part of my answer is [that] too little at this moment [is] available or too little [is] done with our policymakers. They are too much focusing on the smaller things.” (Policy maker 3)

The interviewees pointed towards three major obstacles to being able to provide the learning experience they wished to offer. Firstly, a clear long-term vision with reachable stepping stones. Secondly, a lack of documented good practices. Thirdly, the current structures of higher education.

National Policy Meetings

Following the frontrunner runner interviews the first round of policy meetings took place. A recurring topic across the first round of meetings pointed towards the inclusion of students in these policy meetings and a request for accessible platforms. For example, one meeting report on a policy meeting where students had been included emphasised that the students tended to ‘think outside of the box’. It was also argued that including students would help to empower them. Especially in the national policy meetings of Austria, Romania and the Netherlands a need was expressed for the development of platforms for sharing tools, good practices and insights about transdisciplinary honours programmes that work.

The second round of national policy meetings disseminated the findings of the first two labs and the concept of transdisciplinarity. The Organisation for Economic Co-operation and Development [OECD] definition of transdisciplinarity was the starting point with which participants agreed but felt that the importance of transdisciplinary collaboration was not emphasised sufficiently. Further leverage points for the implementation of transdisciplinary learning into higher education were also discussed. An additional point brought up in the second round was making wicked problems part of teacher education, so that teachers can build the skills to formulate wicked problems in such an educational manner.

During the third round of national policy meetings the activities of the third innovation lab and international policy meeting at Linz were disseminated. The meet-up raised two practical

concerns about teaching and quality assurance. Firstly, participants agreed teachers need different teaching skills in innovation labs than those they are usually trained in:

> "Teachers in innovation labs need to develop skills that are different from those traditionally emphasised, including students-teachers trust, the ability to think creatively, to link practical and theoretical knowledge, to be interdisciplinary." (Policy maker).

Participants pointed out that teachers need to be able to facilitate a safe space, build trust, show empathy and understanding, be adaptive and think creatively. In an innovation lab the teacher is not the expert on the topic who tries to transmit his knowledge and insight to students. Instead, the teacher is a guide, helping a group of students along their personal research journey. This means that a teacher is less in control over what is learnt and holds a supportive role to the student's learning path.

The second insight gained from this third round is that transdisciplinarity is not (yet) an evaluation criterion for degree programs. The quality of an innovation lab also depends on other factors such as the quality of coaching by educators, clear-set guiding principles, clarity of the program structure, and the team dynamics. The lab requires continuous evaluation based on a clear methodology, constructive alignment with learning objectives, and a framework of competences for students. This can be done through regular feedback and reflection sessions with participants, facilitators, and societal actors. However, right now quality assurance remains a perceived barrier for the implementation of transdisciplinary innovation labs.

Transdisciplinary innovation labs — post-lab evaluations

The post-lab evaluations report that participants highly valued strong moderatorship during the lab, site-visits to gain hands-on experience of the challenge, and the use of a framework to structure the learning experience throughout the lab. One student highlighted the horizontal communication between student and teacher as a strong point: "The two-way communication and interaction between moderators and participants was very smooth. I was able to see resistance and resilience for change is appreciating." The participants also noted that the interactive nature of the lab and heterogeneity of the groups in terms of nationality and disciplinary background helped to deepen their insight and establish deeper connections within their teams. Another student's take away was:

> "Importance to talk with all different people from different countries. I also see that we should include information about our aims and goals, like talent pedagogies. Although we only had external partners as speakers and during the trip, this Venice Lab was very rich with respect to information, meetings, insights concerning citizen science. I like a (better) mix between culture and nature. The talks with all participants were great." (student).

A point for improvement was "to make sure there is a good time management and respect the time limit when going around the circle for input" (student). These strengths and weaknesses were subsequently incorporated into the next innovation lab organised by Klaipeda University.

The post-lab evaluation after the Klaipeda lab showed that the in-depth knowledge into sustainability provided by experts in the field at the start of the Klaipeda lab was a good addition. “All of the lectures in the beginning were really interesting and I learned a lot from them! But also hearing all the different solutions to the SDGs [Sustainable Development Goals]” (student). Like in the first lab, a lot of respondents emphasised the value of strong moderatorship by the organising project partner from Klaipeda University and the use of the SDGs as a roadmap. “Getting to know my team members. working on the project together, online, collaborative gave me a sense of satisfaction - that together, with each contribution we can build something” (student). The students enjoyed the freedom that was given to student teams to choose their own project topics after a series of presentations on the SDGs. “Providing us with a broad and intense field of research after which we had the opportunity to choose a topic, but with great flexibility” (student).

However, a difficulty again was the time limit given to complete the tasks. Often resulting in a need to make pragmatic decisions as the quote below shows.

> “I don't think we had the right amount of time to focus on the reality of the problem. Most of the groups (ours too) took many things for granted because of time limits. I think that finding the right problem is much more important than finding a creative solution that may lack applicability or that solves the wrong problem.” (student).

The Linz lab applied the good practices from the previous two labs and added a practical workshop for the participants to learn how to use a toolkit especially designed to create fun solutions for societal challenges. The toolkit supported students to creatively link talent development programs further down the educational chain towards primary and secondary education. The students applied their knowledge and experience from their own education in practice. They were challenged to develop a transdisciplinary approach or a tool or a method to strengthen primary, secondary, and tertiary education for the challenges of the 21st century.

The evaluation again showed similar results to the first two labs. The additional practical workshop was experienced as inspiring and beneficial by participants to gain insight into how a STEAM+ approach to societal challenges incorporates both insights from STEM and non-STEM fields. “Gamification can help with fulfilling the purpose and focus of education and individual development,” one participating student reflected. The most impactful part of the programme for students was “the interactive segments of presentations: when we talked about giftedness, when we made those cars, when we played with coding.” Another student replied.

> “The practical workshops with Sense Box and 3D printing because they were new. I also liked the last day activity - educational stakeholders, from students to policy makers sitting together and discussing about innovation in education.”(student)

However, as the following quote sums up, students also hold an interest in project continuation and being able to integrate new ideas into their activities at their own universities.

> “Well, we have delivered separate 'outputs' from each of the labs: Venice was specific to the locality; Klaipeda was separate partner campus specific; and Linz seemed to be international focus. My suggestion would have been to have some outputs that can be continued by students at each partner; perhaps continuation of the separate campuses’ ideas generated by Klaipeda lab...something concrete that lasts longer than the STEAM+ project for students.” (student)

Online Questionnaires

At the last stage of the project, we aimed to gather some additional data on profile specific perspectives towards implementing transdisciplinary innovation labs through online questionnaires. Students, teachers and policy makers were invited. The results revealed some intriguing insights; however, the overall response rate was too low to draw definitive conclusions (cfr. table 4). While the data gathered offered a glimpse into potential trends, the insufficient number of responses prevents us from considering these findings as fully representative or statistically valid. Further research with a larger sample size is needed to confidently interpret the results.

International policy meeting

Finally, at the international policy meeting in Linz eight policy makers from partner countries were interviewed. Three important points were raised and emphasised by policy makers in the interviews:

1. There may be a limit to the size of an innovation lab;
2. Start with small curricular changes;
3. Establish connections with the labour market early on.

First, policy makers questioned the possibilities of innovation labs with large groups of students. For example: “It's difficult to conceive this type of teaching if you have 100 students” (Policy maker a). Second, policy makers advised higher education institutes to start with small stepping stones such as implementing one or two elements into already existing courses and not to wait around. The two following quotes are indicative of this advice: “If you want to go transdisciplinary or work, you need collaboration, so it's easy to start. Start small. That's perhaps also the best thing. Started with a small project. Start with a few students.” (Policy maker b) Small experiments such as these can help provide local policy makers with data they need to leverage the benefits of the STEAM+ pedagogy further.

> “Make an art of failure or always look at what goes wrong and learn and then just do it in your education. Why should it be so difficult and all legalised, organised? Please step away from education, logistics and schedules and bureaucracy and see what happens. [...] [W]e have this inspection that comes and visits the schools and does audits in schools and always when we present our best excellence programmes and also the failed ones. They say, oh, that's nice, so you learned and what are you going to use in the regular system? What can you pick up and put in the regular system? [This] can be very small, can be 1 module. Or just three workshops or well - Cherry picking.” (Policy maker c)

Third, it was suggested to establish contacts early on with the labour market to attract more talented students.

> "I really sincerely I believe in the transitional programmes, so I think that we have to recommend to our universities - Universities board - to take into account not only the from the administrative point of view, because to organise these kind of programmes implies to have different approach in terms of administrative infrastructure and so on, but if we want to have a success and to have have collaboration, real cooperation with the labour market, you have to think about these kind of transitionary programmes and we want to attract talented students, you have to have this kind of honours programme.*"* (Policy maker d)

Theory of change exercise

During the project activities in Linz, data was gathered about the different stakeholder profiles through the writing-an-individual-theory-of-change exercise which were performed by policy makers, teachers and students.

The individual theories of change helped us to identify different stakeholder's perspectives about the need for change in higher education, the ideas about STEAM+ innovation labs, and envision ways to leverage STEAM+ pedagogy into higher education. Teachers argued that the future called for students with the proper skills to address wicked problems, that companies are already seeking out these skills and that students needed help to manifest their potential. Students shared this view, indicating that innovation labs were needed to help prepare ambitious students to tackle complex and wicked problems, and they experienced a need to escape from "their own 'bubble'" (student). Policy makers focussed more on the practical results that innovation labs would bring such as the prevention of unemployment, the enhancement of knowledge through transdisciplinary collaboration, and the development of sustainability in social life, economics, and environment. The current barriers that were brought forth were the lack of institutional-wide networks spanning different disciplines, funding, and supportive policies.

With regards to leveraging a STEAM+ approach, the results of the theory of change exercise provided insight into some of the stepping stones for implementation. For example, an underlying need for closer communication and collaboration between the different stakeholders towards implementation was identified. Participants pointed towards steps of organisation, such as looking for local problems, projects or themes for an innovation lab, or co-defining the educational aims of the lab. Also, starting with a small group of two or three colleagues and possibly students to co-create a pilot course, trying it out and sharing the results may be a way to get funding.

STEAM-TRAIL map

The research results and reflections were processed into a STEAM-TRAIL map. The map serves as a repository and conceptual model, providing a compendium for STEAM+ pedagogy, and a practical tool to inspire and inform policy makers, HEI, students, and teachers in implementing such transdisciplinary innovation labs. We found inspiration for the design of the STEAM-TRAIL map in other projects such as the SeeRRI project's implementation pathway

(https://stations.seerri.eu/), and in the visual design of the Oslo metro map. In figure 2 we provide an overview of the project data collection activities that led to the map.

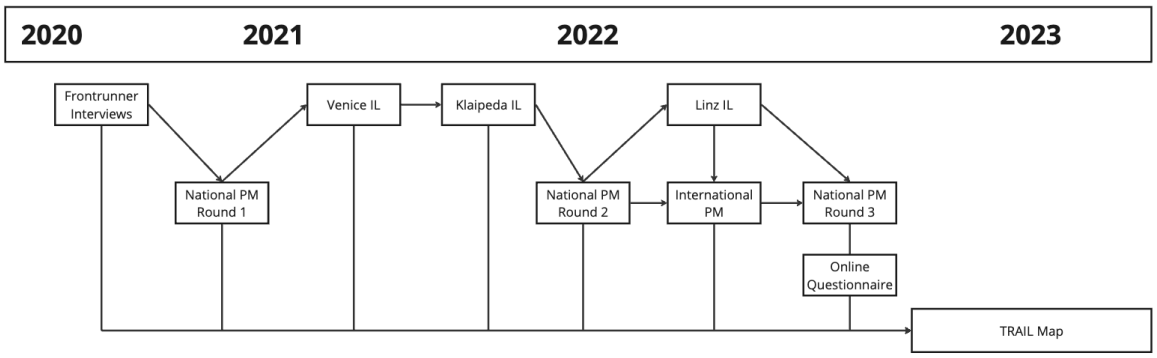

Figure 2: Overview of project activities leading to the STEAM-TRAIL map. (IL = Innovation lab, PM = Policy meeting)

The map expresses and relates the project's insights and learnings about implementing transdisciplinary innovation labs both in terms of appearance and substance. The basic design of the map (figure 3) follows the first-hand experience of project partners who organised innovation labs in the project. In this way it addresses the lack of stepping stones for implementation that were expressed throughout the project. The design starts by introducing key concepts of the STEAM+ pedagogy followed by stepping stones to establish fertile ground. Next, the steps of preparation of a STEAM-TRAIL, carrying it out, and finally improving it are visualised in iterative cycles where regular interactions with policy makers and policy representatives are presented. Visualised as a metro-map an individual 'track' was designed with information targeting each profile (students, teachers, policy makers and higher education policy representatives) resulting in four separate tracks. These run through the five sections which follow the steps for implementation we found through our research. The map can be accessed through: https://steam-plus.vercel.app/trail.

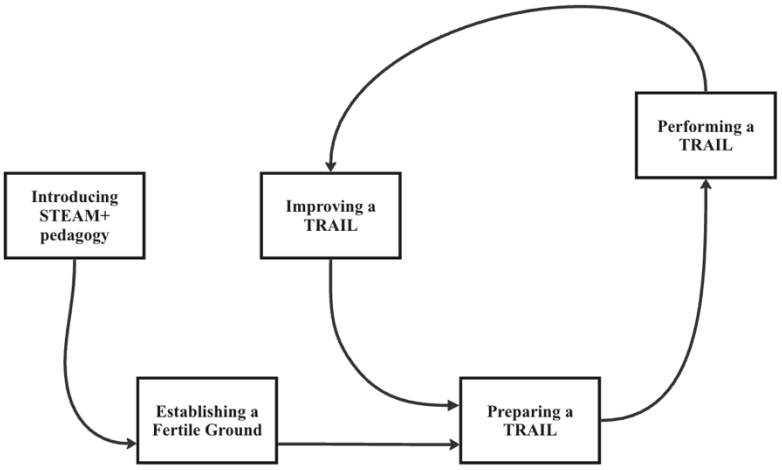

Figure 3: Simplified structure of the STEAM-TRAIL map. Based on STEAM-TRAIL Map (https://steam-plus.vercel.app/trail)

We will now continue with explaining the sections of the STEAM-TRAIL map. Table 5 summarises these sections and indicates the different paths that pass through the STEAM-TRAIL map.The first section runs individually focussing on providing background information and clarifying key topics. In this section the insights from the frontrunner interviews on the need for transdisciplinarity in education, results of the theory of change exercise and the key concepts.

The second section starts when the lines visually start to come together, representing the underlying need identified for closer collaboration and communication between the different stakeholders. In practice we found that some European higher education institutions did not yet have the regulations in place for honours programmes or transdisciplinary courses. This section therefore focuses on the first stepping stones towards implementing an innovation lab for higher education institutes that have little experience with transdisciplinarity and/or honours programmes. These stepping stones are bringing together a community of engaged people, providing information and tools to build up a local and/or institutional working community and having access to some interesting networks to learn from other educational innovators and find practical sources for inspiration. These steps lead to establishing a fertile ground for the innovation lab to be tested and further enhanced in the future.

Sections three, four and five (preparing, performing, and improving a STEAM-TRAIL respectively) run in an iterative cycle. These sections present the practical considerations for educational and instructional design, recruitment, evaluation and further enhancing of the innovation lab. The cyclical centre part of the STEAM-TRAIL map starts and ends at the 'Grand Station'. It indicates the importance for different stakeholders to engage and learn from each other about transdisciplinary innovation labs and its alternative approaches to educating. From the grand station, the teacher and student line run iteratively through preparing a lab, running the lab, and improving the lab. The policy makers and higher education policy representatives are involved in learning from, anchoring and/or improving the STEAM-TRAIL through conversations with teachers and students at the end of each cycle.

As the students and teachers who participated in the STEAM+ activities indicated that they should work together to create the innovation lab a crossroads was designed for students. From this crossroads the student line splits to indicate that students can (and should) co-create innovation labs with the other stakeholders. We have also added a crossroads to the line of policy makers to indicate that they play part in preparing a fertile ground for the innovation lab.

Table 5 shows the division of sections, which stakeholder profiles interact in these sections, and the content of the section. For example, the policy makers are not involved in the lab design, while teachers and student co-creators are. The coming together of different stakeholder lines represents the identified need for co-creation to successfully implement transdisciplinary innovation labs. For example, the goal of the lab should be clear and shared by all stakeholders. More collaboration between different educational stakeholders to overcome barriers to implementation is required. It is important for all voices to be heard, a feeling that is expressed in the reply of one student to the question if students should be part of the co-creation of an innovation lab: "I really hope that you take our feedback in consideration or else, it is a waste of time for many of us" (Student 6).

Table 5: STEAM-TRAIL map sections. T = Teacher, S = Student, HEI = Higher education policy representative, P = Policy maker, S.c. = Student co-creator, P.c. = Policy maker co-creator

Section (first stop → last stop)	Roles	Content
Introducing STEAM+ Pedagogy: Future → Transdisciplinary Innovation Lab		Key concepts: STEAM+, Transdisciplinarity
Establishing Fertile Ground: Fertile Ground → External Network	T, S.c., HEI, P.c.	Making STEAM+ pedagogy possible
Preparing a STEAM-TRAIL: Grand Station → Good Practices	T & S.c.	Addressing practical questions such as lab format, topic, content, …
Performing a STEAM-TRAIL: Recruitment → Outcomes	T , S.c., S.	How to run an innovation lab
Improving a STEAM-TRAIL: Quality → Grand Station	T, S.c., HEI, P.c.	How to further improve and anchor transdisciplinary talent programmes

4. Discussion

Our aim was to explore the barriers, facilitators, and needs of policy makers, students, teachers, higher educational board and policy representatives for implementation of STEAM+ innovation labs. We now discuss the stepping stones for implementation presented by the map and compare some of our results to the recent progress in the field of transdisciplinary education. The STEAM-TRAIL map leverages many of the concerns and barriers that were raised throughout the research and focuses on presenting the steps towards implementation of innovation labs in higher education institutes as to strengthen STEM education. It points towards the need for closer collaboration between different stakeholder profiles at multiple moments to strengthen the implementation of a STEAM+ pedagogy. Transdisciplinary education is still an emerging field of study and further research in for example quality assessment and design effectivity is still needed. This was recently reaffirmed by Horn and colleagues (2022) in their review of the literature that the coverage of transdisciplinary educational programmes remains underreported and that research into the design elements of such courses is still lacking.

The STEAM-TRAIL map presents the stepping stones and common building blocks for a transdisciplinary innovation lab through first-hand experiences with different stages of implementation (introducing, establishing, preparing, designing, performing, and improving). Wolfensberger (2015a) found that there is no uniformity in the type, content, and structure of honours programmes (ibid., p. 13) and their current state of implementation. In a similar way, the STEAM+ pedagogy has different possible designs and formats. Within our project we experimented with different STEAM-TRAIL formats, adjusting them to the local educational possibilities and challenges. Besides these experiences of three new labs during the project, some STEAM+ partners also had previous experiences with organising transdisciplinary innovation labs like the Transdisciplinary Insights honours programme (https://rega.kuleuven.be/if/education-training/tdi/transdisciplinary-insights) at Institute for the Future (https://rega.kuleuven.be/if) from KU Leuven, Belgium, the well-established Dutch research and support for honours pedagogy in higher education (Wolfensberger, 2015b), the inter-university, multidisciplinary international summer schools at Ca'foscari University of Venice named *The Shape of Water* (https://unive.it/pag/30401/), and the undergraduate Honours course at Oslo University (https://www.uio.no/studier/program/honours-programmet/index.html). Such broad variety confirms that case examples from one country or institution might not directly transfer into another context. However, this wide variety of possibilities in innovative pedagogies for higher education is also an opportunity for experimentation.

To experiment with transdisciplinary pedagogical approaches in extracurricular or honours programmes was expressed earlier by Holman and his colleagues in 2009. They found that talent programmes are a good area for educational innovation and experimentation (Holman et al., 2009). Starting with small changes in already existing courses, such as implementing some type of formative analytics or organising a field visit to a local company, can help learners to reflect on what is learned and where they can further improve (Herodotou et al., 2019) or help relate their course materials with real world experiences (Vass & Kiss, 2023).

One important commonality amongst transdisciplinary innovation labs is the need to connect the classroom to the local environment. In 2011 researchers Parsons and Taylor argued for the connecting of classroom material with the local environment to stimulate a better learning experience. They are of the opinion that there is a chance that students don't transfer their knowledge beyond the classroom if the environment is sterile and lacking context (Parsons & Taylor, 2011). In addition, the STEAM+ approach is applied to complex challenges that are non-linear and require collaborative problem solving between students and societal actors (Wolfensberger, 2024). By taking local challenges students can establish a deeper connection with the project. Local challenges also open the possibility for field-visits, improving motivation and the sense of project ownership.

The stepping stones found in our results point out a need for close collaboration between different educational stakeholders. It is essential that all participants share a common understanding of key concepts and a common aim for transdisciplinary education. To enhance STEM education through the implementation of a STEAM+ approach researchers, policymakers and practitioners need to form more and deeper collaborations to support innovation labs. This collaboration plays a pivotal role in empowering students through their learning journey (Smeers et al., 2020). Our results presented above and their visual valorisation in the form of a STEAM-TRAIL map show that the implementation of a

transdisciplinary innovation lab concerns more than just course design and especially collaboration between more than one type of actor.

Limitations of the study

One limitation of this study is that all authors and researchers were actively involved in both the designing, executing, and analysing of the research. Wolfensberger was the project leader and main applicant of the research and is the shared last author of this manuscript. While this close involvement provided valuable insights and ensured a thorough understanding of the research process, it may have introduced potential biases. To mitigate this, the findings and results were reviewed and discussed at different stages with multiple people, amongst which other project partners, policy makers, and the advisory board. This ensured a collaborative approach to data interpretation. Nonetheless, the dual role of researcher and participant could have influenced the objectivity of the conclusions.

A second limitation to this study was The Covid-19 outbreak which delayed our research by almost a whole year. The pandemic's disruptions impacted the design possibilities of the innovation labs and required creativity from the project partners. The first innovation lab in Venice was postponed by twelve months. The second, originally planned to take place in Klaipeda, had to be organised online due to travel restrictions. The third innovation lab in Linz occurred six months later than planned. Despite the setbacks, the twelve-month delay of the first innovation lab allowed us to perform an additional study, the frontrunner interviews. This provided a first impression of the current state of transdisciplinary education programmes in higher education across Europe. This data enabled us to proceed with the first round of national policy meetings as planned, where we discussed and validated the insights of the frontrunners. Additionally, the travel restrictions during the Klaipeda lab allowed for an unexpected opportunity to experiment with digital teaching methods and connecting participants to their local area. In this way we adapted our project to the interruption of the Covid-19 pandemic.

Pathways for further investigation

Throughout the research several new pathways appeared for further research and action. We argue that transdisciplinary innovation labs are important to the enhance STEM education by providing a breeding and testing ground for alternative teaching and learning methods. Given that knowledge on transdisciplinary education is still emerging, and the STEAM-TRAIL map touches upon many different aspects of implementation and educational design, we may point towards different pathways for future research. We choose to focus here on two pathways that our project partners have already embarked upon and a third recommendation towards a review of the online questionnaire which yielded no results in our study.

Firstly, the STEAM-TRAIL map offers cross-context insights and ideas for the implementation of transdisciplinary innovation labs across Europe. Due to the differences between countries and regions in terms of educational policies, the map was not designed as a universal map for implementation in each country. The map offers the building blocks, but these still require an adaptation to the national, regional, or local contexts. Exemplary of this is the TRAILtool at

AVANS university of applied sciences (www.trailtool.org) performed by the Research group Transdisciplinary Cooperation in Education. This research group was founded and is led by Wolfensberger, shared last author of this article and the STEAM+ project leader after the STEAM+ project.

Secondly, our research focussed on the implementation process of transdisciplinary programmes into higher education institutes. We sought to find out how policy makers, students, teachers, and the higher education institute's staff can collaboratively design and implement transdisciplinary innovation labs. However, due to it's conceptual nature the map does not report on the practical teaching strategies that support students to engage in co-creation in transdisciplinary programmes. Sandler, first author of this article has taken this question and developed a PhD research around the topic of teaching for transdisciplinary collaboration under the supervision of the shared last authors, Vandamme and Wolfensberger.

Thirdly, we were unable to deepen our interpretations of the collected data through an online questionnaire. This is not limitation to our research as our aim was not to gather new information from this questionnaire, but intended to gain a better understanding of the particular role that different educational actors can/may take in the implementation of transdisciplinary innovation labs and how their particular needs differ from each other. In future research it can be interesting to reapply this intention to not only identify the needs of different actors, but also to review whether additional actors need to be identified. For example the STEAM-TRAIL map does not include the societal partner. While collaboration with this partner is advisable for example in designing the lab topic.

The recommendations presented above are not exhaustive. Our research identified numerous additional pathways for further investigation for transdisciplinary education. Though we do not expand upon them, several other potential avenues for further research include:

1. Identifying the relationships between course design elements and course outcomes
2. Investigating the implementation of methods from transdisciplinary innovation labs in intra-curricular programmes
3. Continue to explore the impact of students as co-creators of courses, which significantly enhances their learning experience (cfr. Bovill & Woolmer, 2019; Lubicz-Nawrocka & Bovill, 2021)
4. Investigate how a transdisciplinary experience can be leveraged to other educational levels
5. Address the challenges of large classrooms, which often lead to impersonal teacher-student interactions and reduced engagement with course material

5. Conclusion

The aim of STEAM+ was to investigate how transdisciplinary innovation labs may strengthen STEM education. This article provided an overview of the design-based research and the creation of the STEAM-TRAIL map in the STEAM+ project. The STEAM-TRAIL map brings together insights and experiences from across Europe to aid the innovation of higher education for the 21st century. It addresses the need for stepping stones towards

collaborative implementation of transdisciplinary innovation labs between educational actors, including students and policy makers.

We found that implementing transdisciplinary education requires a lot of collaboration at multiple stages with different stakeholders, that stakeholders require clear stepping stones and a shared understanding of what transdisciplinary education entails. The STEAM-TRAIL map serves as a supportive guide for co-creating a STEAM-TRAIL, and a structured knowledge and experience repository of the results of the STEAM+ project. Most importantly, our study has shown the importance of considering the needs and views of all partners involved in transdisciplinary education to co-create an instrument that facilitates educational programmes. The map is a useful tool for teachers, students, policy makers and higher education institutional staff to understand and identify the building blocks needed for the implementation of innovation labs that can enhance STEM education. The map offers a wide range of stepping stones for different institutes across Europe, providing guiding questions, advice, and examples. With its different metro-lines it has visualised the common concern for more and deeper collaboration between educational stakeholders

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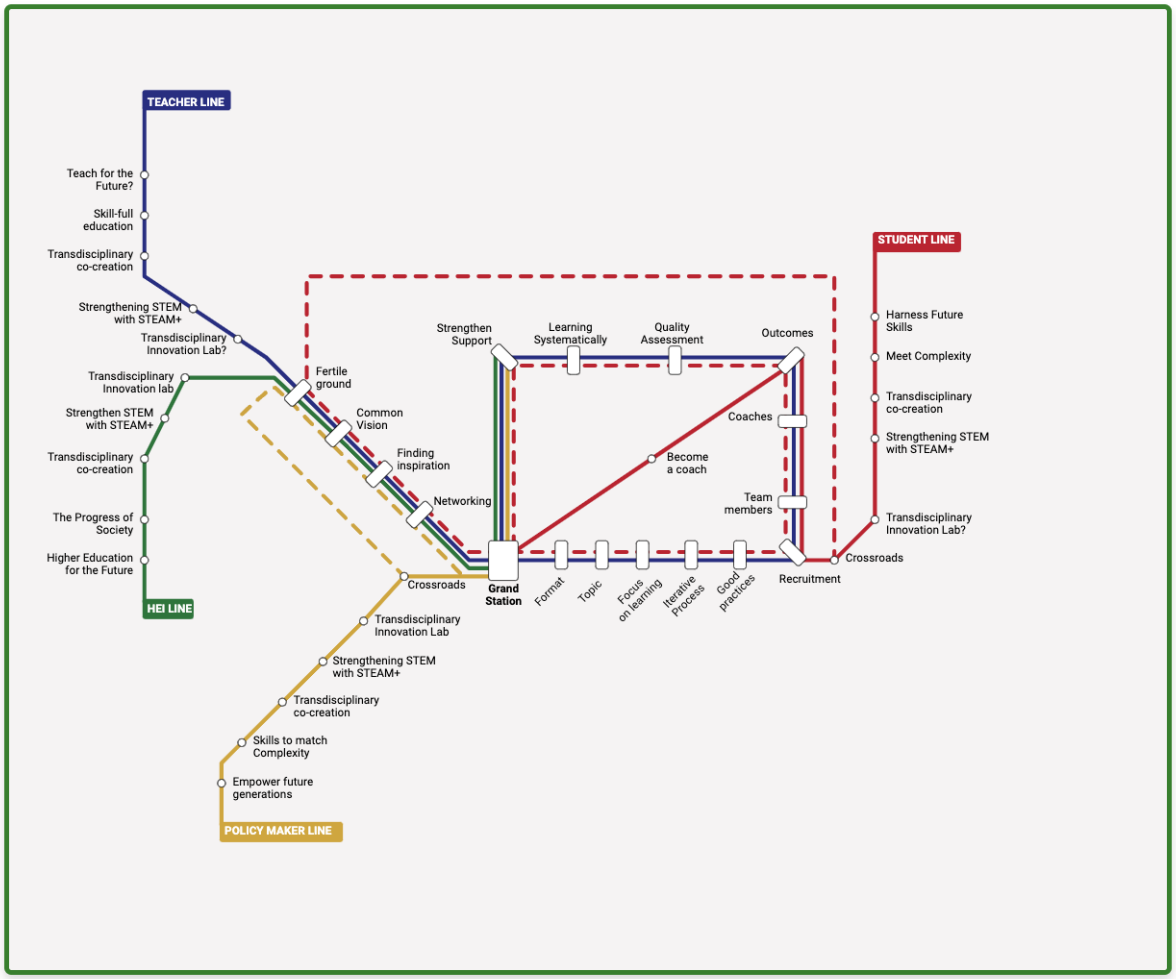
Appendix:

A. STEAM-TRAIL map (https://steam-plus.vercel.app/TRAIL)



B. Frontrunner interview questions

1. What is your background and position?
2. In what sense is Higher Education for the 21st century different from the past?
3. What has changed in society and how does that influence the role/task/goals of higher education?
4. Are institutions for Higher Education adapting (quickly enough) to those needs and goals?
    a. What good evolutions do you see in higher education?
    b. (Or) What keeps them from adapting?
5. Do you think honours programmes can leverage higher educational innovation?
6. (How) can (your) transdisciplinary approaches help to innovate higher education?
7. How can policy makers foster the adaptation of Higher education to the 21st century?
8. Do you have anything that you would like to add?

C. Post-Lab Evaluation Survey template

Meeting evaluation participants

During the Lab, I was a

Student (1)

Teacher (2)

Trainer (3)

Steering group member (5)

Invited expert (6)

I had another role, namely (4) _____

	Strongly agree (1)	Agree (2)	Mostly agree (3)	Mostly disagree (4)	Disagree (5)	Strongly disagree (6)
The time investment to complete the Lab was clear from the start. (1)	○	○	○	○	○	○
I was given enough information about the themes to make a choice for the assignment. (2)	○	○	○	○	○	○
The program of the Lab was well balanced. (3)	○	○	○	○	○	○

The Lab was well organised. (4)	○	○	○	○	○	○
There was always someone to help with questions. (5)	○	○	○	○	○	○
I felt welcome/at ease in my group. (6)	○	○	○	○	○	○
I've learned a lot during this Lab. (7)	○	○	○	○	○	○

Please indicate for each statement below whether you agree or not:

Can you give your 3 strongest points of the Lab?

○ Strong point 1 (1) _____

○ Strong point 2 (2) _____

○ Strong point 3 (3) _____

What was your favorite activity during the Lab?

Can you give 3 suggestions to improve upcoming labs? What could have been done differently and can help organisers of new labs?

○ Suggestion 1 (1) _____

○ Suggestion 2 (2) _____

○ Suggestion 3 (3) _____

Display This Question:
If During the Linz Lab, I was a = Invited expert

How did you experience the transdisciplinary approach of the lab in your role as expert?

What went well in the interaction with the participants and were there challenges you had to face?

Did you have any specific expectations before participating in the lab?
Yes, my expectations were: (1) _____
Not really (2)

Did the Lab meet your expectations (once you've started the lab)?
Yes (1)
Mostly yes (2)
Not completely (3)
No (4)
If you'd like to elaborate on your answer to the above question, you can do so here:

What are the main things you personally take home from this Lab?

Do you think that participation in this Lab will be relevant for you as a future citizen/professional?
Yes (1)
Mostly yes (2)
Not completely (3)
No (4)
If you'd like to elaborate on your answer to the above question, you can do so here:

Has the lab provided you with knowledge/insights/competences that will help you to make a step forward in your personal or professional goals?
Yes, both in personal and professional goals (1)
Yes, in personal goals (2)
Yes, in professional goals (3)
No (4)
If you'd like to elaborate on your answer to the above question, you can do so here:

Which part of the program made the most impact on you and why?

Which part of the program was the most transdisciplinary for you and why? Please give some examples.

Did you have prior experience with transdisciplinarity outside of the STEAM+ project?

Yes, I have previous transdisciplinary experience from (1) _____

No (2)

Display This Question:
If During the Linz Lab, I was a = Student
Or During the Linz Lab, I was a = Teacher
Or During the Linz Lab, I was a = Trainer

How did you experience the transdisciplinary cooperation in your team?

Which part of the program was the most innovative for you and why?

Would you like to co-create an innovation lab in the future at your own institution?
Yes (1)
No (2)
Most likely yes, but I would need additional help with the following topics: (3)
other: (4)

Did you also participate in the one of the other labs from STEAM+?
Yes, the Venice Lab (1)
Yes, the Klaipeda Lab (4)
Yes, both the Venice and Klaipeda Lab (5)
No (2)

Display This Question:
If Did you also participate in the one of the other labs from STEAM+? = Yes, both the Venice and Klaipeda Lab

What was your experience with the difference in design of the labs, being hybrid (online internationally, live nationally) in Klaipeda and being live in Venice and Linz? Is there something about this that you would like to share?

Display This Question:
If Did you also participate in the one of the other labs from STEAM+? = Yes, the Venice Lab

What was your experience with the difference in design of the labs, between the Venice and Linz Lab? Is there something about this that you would like to share?

Display This Question:
If Did you also participate in the one of the other labs from STEAM+? = Yes, the Klaipeda Lab

What was your experience with the difference in design of the labs, being hybrid (online internationally, live nationally) in Klaipeda and being live in Linz? Is there something about this that you would like to share?

Display This Question:
If During the Linz Lab, I was a = Student

Would you like to have education like the Lab in your regular study program? How would you promote this kind of education in your own institution?

Is there anything else you would like to share for the moment? Please feel free to do so here:

Was there another question you'd expected in this survey? If so, please specify:

D. Policy maker Structured Interview Questions, Linz 2022

1. What is your Name and Country, and what Institution do you represent?
2. What were your Reasons for participating in the STEAM+ Policy Meet Up in Linz?
3. You visited the innovation lab during the meet up. What do you think about this format, and can you imagine hosting innovation labs in your country/at your institution?
4. What inspired you the most during the Meet Up?
5. How will you make use of the Inspiration and Knowledge obtained in this Meeting, when you get back Home?
6. What Advice would you give other Higher Education Institutions that want to develop their Programmes to meet the Demands of the Future?

E. Amended activities of STEAM+ due to Covid-19

Activity Title	Work-package	Proposed changes
M2-M7 (Progress Meetings)	**2**	Planning of Progress Meetings is revised due to COVID-19: • M2 was first postponed from November 2020 to 22-23 April 2021 and will now be held online on these new dates. • M3 (planned in Iasi around April 2021) and M4 (planned in Copenhagen in October 2021) will not take place. Instead, we will have a new M3 in Klaipeda in Nov / Dec 2021. This will be moved online if necessary. • The Policy Meet-up M5 (coinciding with Lab3) is moved to April -May 2022 and renamed M4. This is organised by the Austrian Ministry in cooperation with JKU in Linz. • The original M6 (planned in Leuven in May 2022) is postponed to September 2022 and renamed M5. • The final conference (originally M7) is renamed M6 and is postponed to April 2023.
Advisory Board participation	**3**	The Advisory Board (AB) will be invited to physically join the new M3 instead of M2. Meanwhile, the AB has had a long online meeting with the steering group in November 2020, and will join part of the M2 online meeting in April 2021.
Lab1, 2 and 3	**4**	Planning of Labs is revised due to COVID-19. • Lab1 is postponed from July 2020 to July 2021. This is planned to be held physically in Venice. Preparatory online meetings were held in Oct 2020 and will be held in April 2021. • Lab2 is postponed from June 2021 to November / December 2021. This Lab will be held online, coordinated by Klaipeda University. • Lab3 is postponed from January 2022 to April/May 2022. This Lab is planned to be held physically in Linz.
International Policy Meet-Up and final conference	**6**	The International Policy Meet-up (originally M5, now M4) and final conference (originally M7, now M6) will be rescheduled as detailed above. The national meetings with policy partners will also be rescheduled. We aim to keep the number of meetings as planned, but might need to move meetings online. A first series of online national meetings with policy makers is held Spring 2021.

F. Online Questionnaire for students

1. In what country do you study?
2. How would you define transdisciplinarity?
3. Has your understanding of transdisciplinarity changed throughout the innovation lab(s)?
4. Did you have previous experiences with transdisciplinarity in your education before the innovation lab(s)?
5. How did you learn about the innovation lab(s)?
6. What made you join the lab(s)?
7. According to you, should students be part of the creation of the innovation labs? Please expain how you would see your contribution.
8. As a participating student in an innovation lab, what learning goals (if any) did you set for yourself to achieve by participating? (e.g. development of particular skills or deepening your knowledge on the subject)
9. Were you able to achieve your goals?
10. What helped you achieving these goals? Or what impeded you on achieving these goals?
11. In what aspect did the learning and teaching methods in the lab differ from your regular courses?
12. Are there any methods, topics, or activities from the lab that you would include within your regular courses?

G. Online Questionnaire for Policy Makers

1. What country do you work in?
2. How can policy help transdisciplinarity be translated into practice during the innovation lab?
3. What challenges do you perceive for transdisciplinary innovation labs in your country?
4. What can you do to help overcome these challenges?
5. What policies do you have in place in your country or institution that support the implementation of innovation labs?

H. Online questionnaire for Teachers

1. What country do you work in?
2. How would you define transdisciplinarity?
3. Did you have previous experiences with transdisciplinarity in your education before the innovation lab(s)?
4. What do you as a teacher need to know before creating and organising a transdisciplinary innovation lab?
5. Would you include students in the organisation of the lab? If yes, how?
6. In what aspects did the learning and teaching methods used throughout the innovation labs differ from your regular courses?
7. Was it hard to adopt these different methods?
8. If you were to organise your own transdisciplinary innovation lab, would you do anything differently? Please explain.
9. In your opinion, what learning goals should be set for students to achieve through innovation labs?
10. What teaching methods do you think are key to transdisciplinary innovation labs?
11. Are there elements from the lab that you would implement into your regular courses?